

Mariupol Theatre Bombing

by Lewis Gray

Submission date: 24-Apr-2026 02:32PM (UTC+0100)

Submission ID: 280890809

File name: 43355_Lewis_Gray_Mariupol_Theatre_Bombing_710853_669224294.docx (2.45M)

Word count: 3375

Character count: 19252



University of Wales Trinity of St David:
Ordnance Munitions and Explosives

Academic Year 2025 - 2026

Lewis Gray (2224230)

Scientific Principals of OME Design
Supervisor: Gareth Collett

March 2026

Academic Integrity Declaration

I declare that:

- the thesis submitted has been written by me alone.
- the thesis submitted has not been previously submitted to this university or any other.
- that all content, including primary and/or secondary data, is true to the best of my knowledge.
- that all quotations and references have been duly acknowledged according to the requirements of academic research.

I understand that to knowingly submit work in violation of the above statement will be considered by examiners as academic misconduct.

Abstract

After the Russian invasion of Ukraine, the Donetsk Academic Regional Drama Theatre in Mariupol was destroyed in an airstrike with the Russian Aerospace Forces being held responsible. Following condemnation from the international community for a clear violation of the laws of war, Russia attempted to blame groups like the Azov Battalion for staging a false-flag attack. After investigations from multiple third parties such as Amnesty International who conducted forensic research and interviewed multiple witnesses to understand what happened and what munition was used to destroy the theatre.

Table of Figures

Figure 1: Debris Field Being Cast Northerly and Southerly from Centre of Auditorium.....10

Figure 2: Kingery-Bulmash Calculations 11

Table of Tables

Table 1: Theatre Dimensions [9] 9

Table of Equations

Equation 1: Bare Charge Mass 11

Table of Contents

Academic Integrity Declaration.....	2
Abstract.....	3
Table of Figures	4
Table of Tables.....	4
Table of Equations.....	4
I. Introduction	6
1.1 Background to Conflict	6
1.2 Situation in Mariupol and Theatre Bombing	6
II. Theatre Construction, Location and Witness Testimonies.....	7
2.1 Theatre Location.....	7
2.2 Theatre Layout.....	8
2.3 Witness Testimonies	9
III. Theatre Damage Calculations	10
3.1 Damage Assessment.....	10
3.2 Calculations.....	11
IV. Review of Munitions Employed by Russian Aerospace Forces	12
4.1 Artillery Rounds	12
4.2 Cruise Missiles	12
4.3 Type of Warhead.	12
4.3.1 Armour Piercing	13
4.3.2 Incendiary.....	13
4.3.3 High Explosive	13
4.4 Russian High Explosive Bombs.....	13
4.5 Most Likely Candidate.....	14
V. Conclusion.....	14
References.....	15

I. Introduction

1.1 Background to Conflict

On the 27th of February 2014, after the events of Revolution of Dignity where the pro-Russian president Victor Yanukovich was ousted by pro-European protesters, unmarked Russian special forces crossed the border from Krasnodar and landed in Crimea in order to bring the peninsula under Russian control. After a period of civil unrest and clashes between pro-Ukrainian and pro-Russian groups, an illegal referendum was held which resulted in the unilateral declaration of independence of the Republic of Crimea. Russia immediately recognised Crimea as a 'sovereign and independent state' by decree on the 17th of March, before signing the Treaty on Accession of the Republic of Crimea to Russia on the 18th, which laid out the terms for the integration of Crimea into the Russian Federation. The treaty was then ratified 21st of March, marking the formal annexation of Crimea by Russia.

Ukraine condemned the treaty as a gross violation of international law and called on foreign states to avoid recognising the declaration of independence or the annexation by Russia as federal subjects. As of March 2026, 17 UN member states officially recognise Crimea as part of Russia. After declaring Crimea to be under foreign occupation, The Ukrainian government severely restricted the travel of foreign citizens to and from Crimea and stopped supplying water to the region via the North Crimean Canal, which provided 85% of Crimea's drinking water [1].

Following the invasion, pro-Russian demonstrations against the Revolution of Dignity began in the Donetsk and Luhansk oblasts, two provinces of Ukraine that border Russia and have large Russian minorities. Then, on the 12th of April, a Russian commando unit crossed the border into Ukraine and seized Sloviansk in Donetsk. The Ukrainian army responded with force and recaptured the city after two months of fighting, while the insurgents retreated to Donetsk city. Igor Girkin, who led the commando unit that seized Sloviansk, acknowledged that this marked the start of the war in the Donbas [2]. By August, Ukraine had pacified most of the Donbas. To avoid a total collapse of pro-Russian militias Russia began covertly supplying the Russian-backed Luhansk People's Militia (LPR) and Donetsk People's Militia (DPR) with manpower, tanks, artillery and surface to air missiles. The war in the Donbas would continue for almost 11 years when it became subsumed by the Russo-Ukrainian war on the 24th of February when the Russian army crossed the border in at least ten different axes of advance with the intent to topple the Ukrainian government and annex the Russophonic oblasts of Ukraine.

1.2 Situation in Mariupol and Theatre Bombing

Almost a month after the start of the Russian invasion of Ukraine, or 'special military operation' as it was and is still referred to in Russia, Russian Aerospace Forces bombed the Donetsk Academic Regional Drama Theatre in Mariupol. At the time of the attack, Russia was already being condemned by the international community for numerous attacks against civilians in Ukraine, but this was one of the most reported on violation of the laws of war perpetrated by the Russian army due to the nature of the attack. Mariupol had been under siege by the Russian armed forces and Donetsk People's Militia since the start of the war, given its strategic value as a port city on the sea of Azov. After taking

heavy casualties, the Russians laid siege to the city, cutting off food, gas and water [3]. By mid-March, 80-90% of Mariupol had been destroyed by the subsequent Russian shelling campaign [4]. During the shelling, the theatre was used as an air raid shelter with the Russian word 'дети' meaning 'children' painted outside the building in an attempt to identify the building as a civilian shelter and not a military target [5].

Despite the clear indication that the theatre was not a military target, on the 16th of March 2022 Russia began shelling civilian areas of Mariupol. Shortly after 1000, the theatre was hit by a Russian munition. The bomb shelter in the theatre's basement survived the blast but many people were now trapped beneath the burning debris. Rescue efforts were hampered by repeated attacks on the area by Russian forces [6].

The death toll for the attack was difficult to determine, with casualty counts ranging from 300 [7] fatalities to 600 [8]. Investigations into the attack were conducted in the following months after the attack with Amnesty International concluding the attack was carried out using two 500kg bombs and constituted a war crime.

II. Theatre Construction, Location and Witness Testimonies

2.1 Theatre Location

The Donetsk Academic Regional Drama Theatre, which will be referred to simply as the 'Mariupol Theatre', is located in the Teatral'na Plosha, a public square in the urban centre of Mariupol, itself a major historic port city. Its position within the square made it an important cultural landmark within the city. Its isolated location is also important when determining whether or not the strike that destroyed the theatre was deliberate or accidental.



Figure 1: Location of Theatre in the Square

As can be seen in Figure 1, there are no buildings attached to or are in close proximity to the theatre, suggesting that the theatre was targeted deliberately by Russian aerospace forces.

2.2 Theatre Layout

The building consisted of a ground, first and second floor, as well as a basement that was used as a bomb shelter during the Russian shelling campaign. The theatre could accommodate over 1000 people seeking shelter, most of who were on the ground floor or in the basement during the bombing.

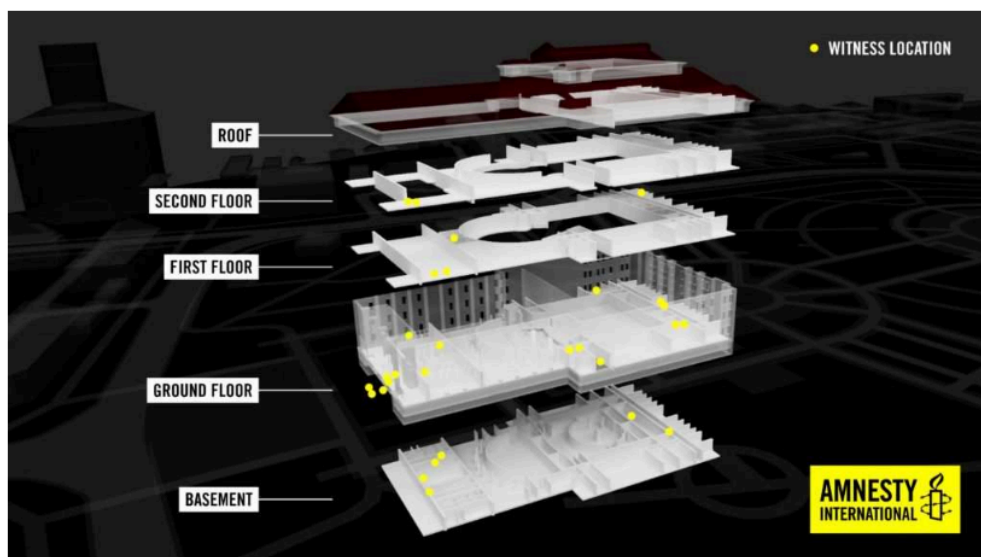


Figure 2: Theatre Layout

As shown by the reconstruction of the theatre in Figure 2, the auditorium section is slightly wider than the main foyer, which will need to be considered to determine the munition used in the attack. The dimensions of the theatre are shown below in Table 1:

Dimensions	Measurements (metres)
Width (Auditorium)	36.78
Width (Foyer)	28.78
Length	68.17
Height	21.96

Table 1: Theatre Dimensions [9]

2.3 Witness Testimonies

After the bombing, witnesses attested to the bombing of the theatre and gave detailed accounts of the series of events that followed. However, perhaps due to adrenaline or shock, many testimonies given by survivors inside and outside of the theatre recall events as happening differently. Most witnesses describe the moment the bomb hit from inside the theatre as being a single explosion, however, Amnesty International concluded that the attack consisted of two 500kg bombs that struck the theatre together and detonated simultaneously after they conducted numerous interviews with witnesses and survivors from inside and adjacent to the theatre. Even then, some testimonies cannot agree on the type of munition used in the attack as Vitaliy Kontarov, a 48 year old lorry driver who was next to the theatre when it was attacked, described seeing 'two missiles fire from one plane towards the theatre' [10]. However, most testimonies collected corroborate one audible explosion with 87% of witnesses attesting to this line of investigation with the remainder recounting hearing two explosions in rapid succession [9].

III. Theatre Damage Calculations

3.1 Damage Assessment

From witness testimony of an airdropped munition striking the theatre and photographic evidence showing the auditorium section of the theatre largely destroyed while the façade on the eastern end of the building being relatively intact, an forensic understanding of what happened can be pieced together in order to calculate the explosive payload required to cause such extensive structural damage to a large mason building.

Witness testimony corroborate that the roof of the theatre was lifted up rather than caved in, meaning the munition punched through the sheet metal roof and detonated within the building itself. This is further confirmed by photographic evidence of the pattern of debris surrounding the theatre being blown out from the centre of the auditorium as opposed to being spread along one axis of origin.



Figure 3: Debris Field Being Cast Northerly and Southerly from Centre of Auditorium

The images detailing the scale of the destruction clearly indicate a large munition capable of delivering 10psi (69.8Kpa) at one half of the building width. It should be noted that reflected blast

overpressures are in excess of incident overpressures, contributing to further damage to the structure.

3.2 Calculations

In order to determine the munition used to attack the theatre, the Net Explosive Quantity (NEQ) must be calculated using Kingery-Bulmash equations, shown below in Figure 2:

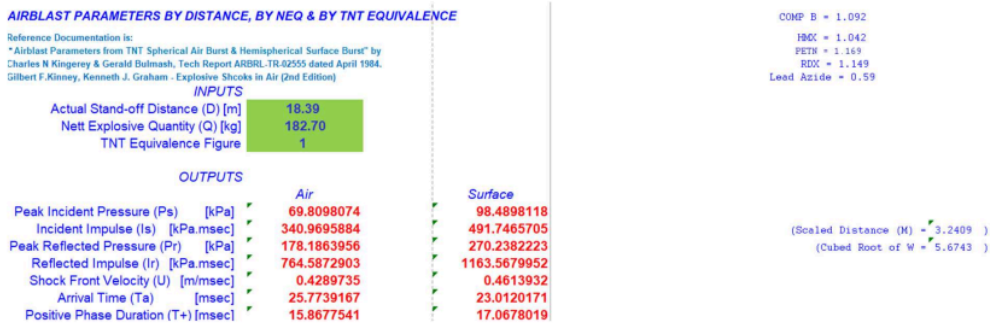


Figure 4: Kingery-Bulmash Calculations

After calculations, it was understood that approximately 182.70Kg of TNT was required to generate the 10psi (69.8KPa) overpressure that caused major structural damage to the theatre. The Scaled distance required to produce 69.9KPa at 18.39m was calculated at 3.24mkg^{-1/3}, according to the Kingery-Bulmash matrix. Although an NEQ of 182.7kg is stated, this is for the total of explosive materials in the charge in terms of TNT equivalence and does not represent the total mass of the munition which will include additional components such as a metal case.

The bare mass charge can be calculated using the equation:

$$W_b = \left(\frac{r}{Z} \right)^3$$

Equation 1: Bare Charge Mass

Where: W_b is the Bare Charge Mass (kg)

R is the distance required for incident overpressure (metres)

Z is the scaled distance.

The bare mass charge was calculated to be 182kg. This does not factor in TNT equivalence where the explosive power of chemical compounds is a multiplier of the explosive power of TNT, meaning that a compound with a high TNT equivalence such as torpex (TNT equivalence of 1.67) requires less mass to deliver the same yield.

IV. Review of Munitions Employed by Russian Aerospace Forces

Now that the mass of explosive filling of the munition has been determined, the type and designation of the munition can be interrogated by combining calculated values with witness testimonies.

4.1 Artillery Rounds

Rounds such as 152mm artillery shells typically used by the Russian Ground Forces as it contradicts witness testimonies that specifically an air-launched munition from an attacking aircraft was responsible for destroying the theatre. Additionally, artillery rounds are imprecise and inaccurate, being deployed en masse to maximise fire effect and destruction. The Russian army does possess accurate, precision guided artillery rounds such as the 2K25 Krasnopol 152mm round, fired mainly from Russian self-propelled artillery guns (SPGs) such as the 2S3 Akatsiya and 2S19 Msta-S. However, these can also be ruled out as the munition that destroyed the theatre originated from an attacking aircraft.

4.2 Cruise Missiles

Cruise missiles such as the 3M54-1 Kalibr and 3M14 Biryuza have been employed by the Russian armed forces since the beginning of the conflict, mainly to target strategic targets such as airfields, fuel depots, ammunition dumps and infrastructure targets. These large munitions are normally carried by heavier Russian aircraft such as the Tu-22M3 'Backfire' bomber. However, while a cruise missile attack is corroborated by some witnesses who report that a Russian aircraft fired two missiles towards the theatre, Russian army doctrine at that point early in the invasion differs from this scenario and makes a cruise missile attack unlikely. Amnesty International notes that in the opening months of the invasion, Russia didn't employ cruise missile strikes in support of ground assaults. Rather, they were almost exclusively used to attack single tactical targets. At the time of the theatre bombing, a Russian ground assault was underway nearby in the city, corroborated by witnesses saying fighting was taking place in surrounding neighbourhoods. Forensic evidence of munition debris also removes cruise missiles from the pool of candidate munitions as pieces of the Kalibr missile that struck the Rivne television tower were found to be unlike the fragments recovered from the rubble of the Mariupol theatre.

4.3 Type of Warhead.

It is important to note the type of warhead when attempting to determine the munition responsible for the bombing as doing so can greatly reduce the pool of candidate munitions and narrow down the culprit. Three of the most common types of warheads used on air dropped munitions are high explosive (HE), incendiary and armour piercing (AP).

4.3.1 Armour Piercing

Armour piercing or derivative munitions such as semi-armour piercing (SAP) munitions are doctrinally used to defeat armoured targets such as bunkers, tanks and fortified targets. The Mariupol theatre was an unarmoured civilian target constructed of mason with a sheet metal roof. Such a target would not have been targeted with such munitions, especially that early in the war when Russia didn't have the munition shortages it has suffered latterly in the conflict. Such bomb work by increasing and reinforcing the munition casing, leaving less room for HE filler, meaning that AP and SAP bomb would likely fall short of the 182kg NEQ required to produce the 10psi overpressure.

4.3.2 Incendiary

Incendiary bombs create instantaneous infernos upon detonation. This is inconsistent with witness testimonies that state upon detonation there was a powerful blast that knocked people unconscious and destroyed the mason walls of the theatre. Images of the aftermath also do not support the use of incendiary munitions as there are no heavy scorch marks on the rubble to suggest a large fire.

4.3.3 High Explosive

The use of an HE munition to destroy the theatre is the most likely scenario. It is corroborated by witness testimonies that a powerful blast was generated by the munition and the structural damage to the theatre is consistent with that generated by a cylindrical HE charge. It is also one of the most common munitions carried by Russian Air Force close air support (CAS) multirole fighter-bombers such as the Sukhoi Su-27 'Flanker' series airframes and its derivatives such as the Su-34 'Fullback'.

4.4 Russian High Explosive Bombs

The most likely candidates are the Russian FAB-500 500kg HE bombs carried by most airframes of the Russian Aerospace forces due to considerations of NEQ and analysis by third parties such as amnesty international. Such bombs typically have an NEQ of 195kg [11]; the discrepancy between the calculated value and the given value for the munition can be explained by the HE filler used by the Russians being a mix of compounds. These bombs have three fuse settings: impact, short delay and factory, which is a longer delay of about a tenth of a second; making these munitions ideal against buildings. It also corroborates witness statements about the roof being blown outward, suggesting the bomb went through the roof before the delayed fuse detonated the munition.

There are two main variants of the FAB-500 are the FAB-500M-62 and the KAB-500S-E. The main difference between them is the guidance method used in their delivery. The FAB-500M-62 is unguided apart from the continuously calculated impact point (CCIP) the pilot uses to estimate where the bomb will land. The KAB-500S-E is far more sophisticated and uses the Russian GLONASS system (Russian equivalent of GPS) to guide bombs to their targets.

4.5 Most Likely Candidate

Examining the geographical position of the theatre in Mariupol, being isolated in a public square with no other candidates for attack within over one hundred metres, it can be said with certainty that the theatre was targeted in the bombing run that destroyed it. To hit such an isolated target would require the use of a guided munition. Therefore, the guided KAB-500S-E is the most likely culprit responsible for destroying the Mariupol theatre. It also corroborates some witness testimonies that claim two bombs or munitions were utilised against the theatre as the circular error probability (CEP) for unguided bombs is well out with the roughly 1000m² of the auditorium. The CEP of the KAB-500S-E is 7-12m [12] which makes it more suitable for precision bombing.

V. Conclusion

In conclusion, from forensic examination of the blast site, calculations into the NEQ of the munition used to generate 10psi overpressure which destroyed the building and consideration of witness testimonies, the most likely candidate munition that was responsible for destroying the Mariupol drama theatre was the Russian KAB-500S-E satellite guided HE bomb. Since there were no other possible targets adjacent to or anywhere near the theatre a precision guided munition must have been used to effectively hit and destroy the structure. This also reflects the intent behind the attack, that a stray bomb would be unlikely to unintentionally hit the theatre, meaning the attack was a deliberate violation of the laws of war on Russia's part. The KAB-500S-E is also consistent with witness testimony that a Russian aircraft was responsible for the theatre's destruction, being a bomb that is typically carried on Russian multirole fighter bombers such as the Flanker series of airframes.

References

- [1] M. Mirovalev, "Dam Leaves Crimea Population in Chronic Water Shortage," Aljazeera, 4 January 2017. [Online]. Available: <https://aljazeera.com/features/2017/1/4/dam-leaves-crimea-population-in-chronic-water-shortage>. [Accessed March 2026].
- [2] A. Dolgov, "Russia's Igor Strelkov: I Am Responsible for War in Eastern Ukraine," The Moscow Times, 21 November 2014. [Online]. Available: <https://www.themoscowtimes.com/2014/11/21/russias-igor-strelkov-i-am-responsible-for-war-in-eastern-ukraine-a41598>. [Accessed April 2026].
- [3] RadioFreeEurope / RadioLiberty, "Historic Theatre Sheltering Mariupol Civilians Hit By Air Strike, Number of Casualties Unknown," 16 March 2022. [Online]. Available: <https://www.rferl.org/a/ukraine-mariupol-theatre-destroyed-strike/31756641.html>. [Accessed April 2026].
- [4] L. Tondo and J. Henley, "Survivors Leaving Basement of Mariupol Theatre After Airstrike, Say Officials," The Guardian, 17 March 2022. [Online]. Available: <https://theguardian.com/world/2022/mar/17/mariupol-theatre-ukraine-civilians-russia-war>. [Accessed April 2026].
- [5] A. Hayes, "Ukraine War: People Buried Under Rubble After Mariupol Theatre Sheltering Hundreds is Hit by Russian Bomb, Officials Say," Sky News, 17 March 2022. [Online]. Available: <https://news.sky.com/story/ukraine-war-mariupol-theatre-where-hundreds-of-people-sheltering-bombed-by-russian-forces-officials-claim-12567393>. [Accessed April 2026].
- [6] H. Bachega and O. Khimiak, "Mariupol Theatre: 'We Knew Something Terrible Would Happen'," British Broadcasting Corporation, 17 March 2022. [Online]. Available: <https://www.bbc.co.uk/news/world-europe-60776929>. [Accessed April 2026].
- [7] D. Harding, "UN Says Evidence of Mass Graves In Mariupol as Russia Hints at Scaled-Back War," Independent, 25 March 2022. [Online]. Available: <https://www.independent.co.uk/news/world/europe/ukraine-mariupol-theatre-bombing-death-toll-b2043871.html>. [Accessed April 2026].
- [8] L. Hinnant, M. Chernov and V. Stepanenko, "AP Evidence Points to 600 Dead in Mariupol Theatre Bombing," Alternative Press, 4 May 2022. [Online]. Available: <https://apnews.com/article/Russia-ukraine-war-mariupol-theatre-c321a196fbd568899841b506afcac7a1>. [Accessed March 2026].
- [9] G. Collett CBE CEng MSC BSc (Hons) FIEpE, "Explosive Engineering Assessment - Donetsk Regional Academic Drama Theatre in Mariupol, Ukraine," 16 November 2022. [Online]. Available: <https://theatre.spatialtech.info/reports/BCL-response%20Spatial%20Technologies.pdf>. [Accessed April 2026].

- [10] "Ukraine: Mariupol Theatre Attack Was 'A Clear War Crime' - New Investigation," Amnesty International, 30 June 2022. [Online]. Available: <https://www.amnesty.org.uk/latest/ukraine-mariupol-theatre-attack-was-clear-war-crime-new-investigation/>. [Accessed April 2026].
- [11] "FAB-500S-E," GlobalSecurity.org, [Online]. Available: <https://www.globalsecurity.org/military/world/russia/fab-500m-62.htm>. [Accessed April 2026].
- [12] "KAB-500S-E," ROBINSONEXPORT, [Online]. Available: <https://www.roe.ru/en/production/aerospace-forces/air-weapons/guided-weapons/korrektiruemye-i-upravlyaemye-aviatsionnye-bomby/kab-500s-e/>. [Accessed April 2026].

Mariupol Theatre Bombing

GRADEMARK REPORT

FINAL GRADE

63 / 100

GENERAL COMMENTS

Hi Lewis,

A good submission, well done. You clearly understand the concepts of SPOME applied to blast, which was the purpose of the assignment. You scored a strong 2:2 and the rubric allocation is shown below, with some detailed comments. Have a think about bare mass equivalents and how this may have influenced your answer.

Engagement with literature skills

9/15. Engagement with a wide range of research-informed literature, including sources retrieved independently. Selection of relevant and credible sources. Very good use of referencing, with no/very few inaccuracies or inconsistencies.

Knowledge and Understanding

16/25. Excellent coherent and detailed knowledge and systematic understanding of the principles and theories of SPOME. Clear awareness of challenges to established views and the limitations of the knowledge base.

Cognitive and Intellectual Skills 13/20. Excellent critical thinking, analysis, synthesis and evaluation. Ability to investigate contradictory or incomplete information and make strong, persuasive, arguments and sophisticated judgements. Some evidence of independent thought and ability to 'see beyond the question', suggesting a grasp of the broader field and wider concepts.

Practical Application 12/20. A good and appropriate application of standard methods, materials, tools and/or techniques. Clear appreciation of the context

of the application. Mainly consistent, accurate and logical application of theory to practice, making appropriate links between the two. Can identify problems and propose mostly appropriate solutions in complex and unpredictable contexts.

Transferrable Skills 13/20. Can communicate well, confidently and consistently in a suitable format. Work is coherent, fluent, well-structured and organised. Demonstrates very good graduate employment skills, with just occasional minor weakness.

In detail:

1. In the abstract, please state what you found out as a summary to the report. What do you think it was?

2. The structure is well laid out. But, please place your lists of figures, tables and equations below the main TOC.

3. Excellent introduction, to the conflict. Perhaps more than needed.

4. I really liked figure 1, which shows the isolation of the theatre compared to other structures and the markings that say 'children'.

5. Figure 2 is also powerful, and clearly shows the location of people in the building who provided witness testimony. You could have shown a figure that demonstrates the open space of the auditorium, and how this welcomed blast waves.

6. Witness testimony discussion could have been longer and required a technical reference for why human factors allows people to recall events differently. We will never really know if it was one or two blasts.

7. Excellent description of the damage to the theatre and good pointers to internal blast.

8. Calculations accurate, but what about bare charge mass equivalent?

9. I think pages 12 and 13 would have been better served with a table of sorts, clearly defining the types of munition. Nothing wrong with how you have discussed in the text, but it needs more focus.

10. You could have included a statement on dumb vs guided for the FAB/KAB 500 series. CEP was important if two strikes, and you nailed this part. CEP for FAB is about 30 m at a particular altitude.

11. Strong conclusion. Well done. Think about what you should have placed in the abstract from this.

12. Referencing was well applied. Would have expected to see more for this aspect of work.

PAGE 4

PAGE 5

PAGE 6

PAGE 7

PAGE 8

PAGE 9

PAGE 10

PAGE 11

PAGE 12

PAGE 13

PAGE 14

PAGE 15

PAGE 16
